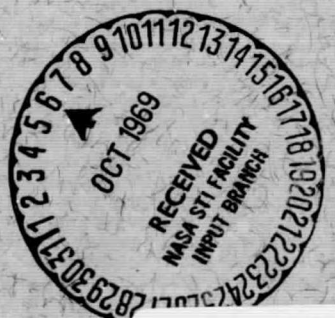
RAYTHEON

Technical Report

PT-2305

THERMIONIC CATHODE EVALUATION STUDY

INTERIM REPORT NO. 8



MICROWAVE AND POWER TUBE DIVISION

MICROWAVE TUBE OPERATION, WALTHAM, MASS. 02154

RAYTHEON COMPANY
Microwave and Power Tube Division
Waltham, Massachusetts

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THERMIONIC CATHODE EVALUATION STUDY

NASA Prime Contract No. NAS7-100
Subcontract No. 951810

April 1 - June 30, 1969

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, sponsored by the National Aeronautics and Space Administration under Contract NAS7-100

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PT-2305
7 August, 1969

NOTICE

ABSTRACT

During the eighth interim period of thermionic-cathode evaluation, diodes using pore-dispenser cathodes have completed at least 14, 784 hours of satisfactory life burning at cathode temperatures of 950°C to 1100°C and at current densities of 0.2 A/cm^2 to 1.6 A/cm^2.

Diodes using standard oxide cathodes have completed life burning cycles varying from 11, 605 to 13, 925 hours. The diodes are showing cathode emission slump at current densities above 0.15 A/cm^2 and cathode temperature of 825 and 850°C.

The diodes constructed with oxide-coated and coated particle cathodes with three different nickel alloys according to Modification No. 1 of the contract show slumping emission with the exception of the coated-particle cathode with A33 nickel alloy. In this case, the emission is showing stability up to 0.45 A/cm^2 for 655 hours.

1.0 INTRODUCTION

The Materials and Techniques Group of Raytheon's Microwave and Power Tube Operation is performing a study of the life capabilities of three different types of thermionic emitters under varying cathode temperature and current loading conditions for the Jet Propulsion Laboratory, California Institute of Technology.

The life capabilities of the following electron-tube cathodes are being evaluated for extended periods of time.

a. Pore-Dispenser Cathode
b. Coated-Particle Cathode
C. Standard Oxide Cathode

The life burning results, for this interim period of study, are reported in Section 2.0 (Pore-Dispenser Cathode) and Section 3.0 (Standard Oxide Cathodes.

The initial testing and life burning results for oxide-coated and coated-particle cathodes with three different alloys constructed according to Modification No. 1 of the contract are reported in Section 4.

2.0 LIFE BURNING AND TESTING OF PORE-DISPENSER CATHODES

The test diodes with pore-dispenser cathodes and operating under T1, T2 and T3 life-test conditions have completed 15,051 hours as of the end of the interim period of study, June 30, 1969.

The test diodes under T4 conditions have completed 14,784 hours of life burning. The life-test results are shown in Tables 1(T1), 2(T2), 3(T3), 4(T4).

The last three sets of readings for each diode are the readings for the months of April, May, and June, 1969.

The diodes were tested for cathode current at a specified constant anode voltage and cathode temperature as noted in each table. The cathode current is also recorded for ± 20% of the specified anode voltage.

The diodes were removed from the life-test rack, at each test interval, and were read for dip temperature at the specified operating current and current at 95% of the operating temperature, according to the procedures described in the First Interim Report, Thermionic Cathode Evaluation Study, January 1 - June 30, 1967.

The diodes operating under T1 conditions (950°C, 0.2 and 0.4 A/cm^2) have not shown any significant changes in life burning or test conditions up to 15,051 hours.

The diodes operating under T2 conditions (985°C, 0.4 A/cm^2) have not shown any changes in characteristics up to this point of life burning. The diodes operating under T2 conditions (985°C, 0.8 A/cm^2) have shown a slump of 19.5% and 14.3% up to 15,051 hours of life burning.

The diodes operating at T3 conditions (1035°C, 0.6 and 1.2 A/cm^2) are satisfactory in operation and test conditions up to this point in life burning.

One diode under T4 conditions (1100°C, 0.8 and 1.6 A/cm^2) has shown a slump of 27.8% in operating characteristics. The other two diodes are showing satisfactory performance at 14,784 hours of life burning.

In summary, the pore-dispenser cathodes have operated satisfactorily for 14,784 hours with the current varying from 0.2 A/cm^2 to 1.6 A/cm^2 with cathode temperature varying from 950°C to 1100°C.

TABLE 1

LIFE TEST RESULTS

PORE-DISPENSER CATHODES

Test	Diode	Hours	Ip (ma)	Volts	Ip ± 20% V	Dip T°C	Ip @ 95%T
T1-950°C 0.2 A/cm^2	M1 Ef=10.2V	0 2688 13048 13809 14423 15051	10.0 11.0 11.0 11.0 11.3 11.8	39	8.4 - 12.0 8.9 - 13.2 9.0 - 13.2 8.9 - 13.1 9.4 - 13.8 9.9 - 14.0	880 891 848 891 831 910	8.75 8.00 8.90 8.62 9.41 8.63
	M4 Ef=10.2V	0 2688 13048 13809 14423 15051	10.0 10.0 9.8 9.8 10.7 10.7	26	8.3 - 12.5 8.4 - 12.2 8.2 - 11.9 8.2 - 11.9 9.2 - 13.2 9.2 - 13.2	888 906 820 835 825 858	8.81 8.25 8.90 8.94 9.22 9.06
T1-950°C 0.4 A/cm^2	M2 Ef=10.2V	0 2688 13048 13809 14423 15051	20.0 21.2 20.6 20.2 20.2 22.0	49	15.1 - 27.3 16.1 - 25.9 16.4 - 24.4 15.9 - 24.0 15.9 - 25.4 17.9 - 27.9	916 896 838 916 860 862	19.3 17.5 18.8 17.5 18.1 17.8
	M3 Ef=10.2V	0 2688 13048 13809 14423 15051	20.0 20.7 20.2 19.0 21.0 21.2	35	16.5 - 27.0 16.2 - 25.2 16.0 - 24.2 15.0 - 22.9 16.5 - 26.4 16.7 - 26.2	897 907 870 900 880 909	15.0 16.6 17.6 17.6 18.2 16.9

TABLE 2

LIFE TEST RESULTS

PORE-DISPENSER CATHODES

Test	Diode	Hours	Ip (ma)	Volts	Ip ± 20% V	Dip T°C	Ip @ 95%I
T2-985°C 0.4 A/cm^2	M7 Ef=10.2V	0	20.0	34.5	16.8 - 27.5	899	19.3
		2688	20.0		15.8 - 24.4	957	16.6
		13048	23.2		18.2 - 28.8	906	18.2
		13809	22.7		18.0 - 28.2	921	17.9
		14423	23.2		18.4 - 29.0	906	18.8
		15051	22.5		18.0 - 28.1	959	16.2
	M9 Ef=10.2V	0	20.0	40	14.6 - 28.5	910	18.8
		2688	22.5		15.9 - 29.1	935	17.7
		13048	21.9		15.8 - 28.1	908	18.1
		13809	22.0		15.6 - 28.6	919	18.1
		14423	23.0		16.2 - 30.2	902	18.8
		15051	22.8		16.2 - 29.9	949	17.0
T2-985°C 0.8 A/cm^2	M11 Ef=10.2V	0	40.0	65	32.0 - 49.5	964	28.0
		2688	37.5		30.8 - 45.8	979	30.3
		13048	34.8		30.2 - 40.3	964	33.4
		13809	34.8		29.0 - 40.7	954	34.5
		14423	34.6		29.0 - 40.4	960	34.0
		15051	32.2		28.1 - 36.0	962	34.5
	M12 Ef=10.2V	0	40.0	54	31.0 - 50.0	913	38.0
		2688	37.0		29.2 - 45.0	957	32.0
		13048	32.1		26.0 - 37.9	891	35.3
		13809	33.2		26.8 - 39.7	888	35.5
		14423	36.2		28.9 - 44.8	873	36.5
		15051	34.3		27.5 - 41.8	889	31.5

TABLE 3

LIFE TEST RESULTS

PORE-DISPENSER CATHODES

Test	Diode	Hours	Ip (ma)	Volts	Ip ± 20% V	Dip T°C	Ip @ 95%I
T3-1035°C $_2$ 0.6 A/cm^2	M-13 Ef=10.2V	0	30.0	45	22.5 - 38.5	965	29.2
		2688	30.0		23.9 - 39.8	961	26.4
		13048	32.4		24.0 - 40.2	913	28.2
		13809	32.1		24.0 - 40.2	942	27.6
		14423	33.0		25.0 - 41.9	895	26.8
		15051	32.6		24.9 - 40.3	1013	31.0
	M-18 Ef=10.2V	0	30.0	48.5	21.5 - 38.0	949	29.2
		2688	30.0		23.0 - 37.8	1003	25.6
		13048	31.8		24.7 - 40.1	961	27.8
		13809	31.8		24.7 - 40.1	1017	24.6
		14423	33.1		26.4 - 41.2	974	24.8
		15051	33.1		26.4 - 41.2	975	17.0
T3-1035°C $_2$ 1.2 A/cm^2	M-17 Ef=10.2V	0	60.0	90	45.0 - 78.5	993	55.5
		2688	61.2		47.8 - 77.4	1020	51.6
		13048	62.4		50.9 - 78.8	1013	53.6
		13809	62.2		50.9 - 78.6	1010	54.4
		14423	62.2		50.9 - 78.7	1035	51.2
		15051	61.0		48.4 - 71.9	1028	52.0
	M-14 Ef=10.2V	0	60.0	98	44.5 - 69.0	995	56.0
		2688	54.9		41.2 - 70.2	977	55.2
		13048	60.9		42.0 - 76.9	965	53.6
		13809	60.9		42.0 - 76.9	946	57.2
		14423	64.0		45.6 - 80.0	927	53.6
		15051	64.1		45.3 - 79.0	938	57.0

TABLE 4

LIFE TEST RESULTS

PORE-DISPENSER CATHODES

Test	Diode	Hours	Ip (ma)	Volts	Ip ± 20% V	Dip T°C	Ip @ 95%T
T4-1100°C, 0.8 A/cm^2	M-21 Ef=10.2V	0	40.0	67	23.8 - 52.0	957	37.6
		2521	46.4		28.8 - 59.5	1055	34.6
		12781	51.9		32.0 - 63.9	1016	34.5
		13506	51.0		31.4 - 63.9	970	36.2
		14120	54.0		33.4 - 67.2	925	37.5
		14784	54.0		33.4 - 67.2	985	32.5
	M-23 Ef=10.2V	0	40.0	73	24.0 - 51.0	997	38.0
		2521	37.2		23.9 - 45.8	1079	31.8
		12781	38.2		25.3 - 47.0	1100	29.5
		13506	37.0		24.9 - 46.3	1069	35.2
		14120	25.9		18.5 - 30.2	1027	32.2
		14784	28.9		20.3 - 33.0	1100	32.0
T4-1100°C, 1.6 A/cm^2	M-22 Ef=10.2V	0	80.0	106	59.0 - 100.0	1039	73.0
		2521	86.5		71.7 - 110.0	1051	66.0
		12781	86.8		74.4 - 110.0	1100	61.0
		13506	85.0		74.0 - 110.0	1045	68.5
		14120	83.0		71.0 - 110.0	985	75.0
		14784	81.9		66.4 - 97.3	1040	72.5

3.0 LIFE BURNING AND TESTING OF OXIDE-COATED CATHODES

The test diodes with oxide-coated cathodes operating under T1 and T2 conditions have completed 11,605 hours of life burning.

The test diodes with oxide-coated cathodes operating under T3 and T4 conditions have completed 13,925 hours of life burning.

The life-test results are shown in Tables 5(T1), 6(T2), 7(T3), 8(T4). The last three sets of readings for each diode are for the months of April, May, and June, 1969.

The diodes operating under T1 conditions (800°C, 0.075 and 0.15 A/cm^2) have shown a slump in cathode operating current of 8.4 to 25.0%.

The diodes operating under T2 conditions (825°C, 0.15 A/cm^2 and 0.30 A/cm^2) have shown a change in cathode operating current from 5% to 43.9%. It should be noted that the dip temperatures are at 825°C.

The diodes operating under T3 conditions (825°C, 0.225 A/cm^2 and 0.45 A/cm^2) are showing cathode current slumps from 0% to 43.3%. The dip temperature is also at 825°C (operating temperature).

Diode No. O-22 operating under T4 conditions (850°C, 0.3 A/cm^2) was a complete emission failure at 13,297 hours of life burning.

The two diodes operating under T4 conditions (850°C, 0.6 A/cm^2) are showing cathode current slumps of 26.8% and 46.1%. The dip temperatures are at 850°C (operating temperature).

An analysis of the test results show the diodes with oxide-coated cathodes to be slumping at current densities above 0.15 A/cm^2.

TABLE 5

LIFE TEST RESULTS

OXIDE-COATED CATHODES

Test	Diode	Hours	Ip (ma)	Volts	Ip ± 20% V	Dip T°C	Ip @ 95%I
T1-800°C 0.075 A/cm^2	O-32 Ef=8.0V	0 1371 9638 10363 10977 11605	6.0 6.0 5.7 5.4 5.5 5.5	19.5	4.7 - 7.9 4.9 - 7.4 4.9 - 6.2 4.6 - 6.0 4.7 - 6.1 4.7 - 6.1	722 666 764 750 732 760	4.13 5.14 4.76 4.27 4.95 4.88
	O-35 Ef=8.0V	0 1371 9638 10363 10977 11605	8.0 7.8 7.2 7.2 7.2 7.2	18.5	7.1 - 9.7 7.2 - 8.9 6.8 - 8.6 6.8 - 8.6 6.8 - 8.6 6.8 - 8.6	750 740 793 790 784 785	4.13 5.14 4.50 4.30 4.84 4.88
T1-800°C 0.15 A/cm^2	O-39 Ef=8.0V	0 1371 9638 10363 10977 11605	12.0 11.8 8.9 9.0 9.0 9.0	36	9.0 - 15.1 8.9 - 14.3 7.0 - 11.6 7.2 - 10.6 7.1 - 10.9 7.1 - 10.9	655 680 738 739 742 706	10.9 10.5 10.1 10.2 10.1 10.1
	O-40 Ef=8.0V	0 1371 9638 10363 10977 11605	12.0 12.0 9.9 9.9 8.8 9.0	29	9.6 - 14.7 9.9 - 14.1 8.3 - 12.1 8.4 - 12.1 7.1 - 10.2 7.1 - 10.9	769 703 770 772 780 766	9.3 10.1 9.8 9.6 9.9 9.8

TABLE 6

LIFE TEST RESULTS

OXIDE-COATED CATHODES

Test	Diode	Hours	Ip (ma)	Volts	Ip ± 20% V	Dip T°C	Ip @ 95%I
T2-825°C 0.15 A/cm^2	O-38 Ef=8.0V	0	12.0	29	9.3 - 15.2	741	11.0
		1371	11.0		8.0 - 13.0	804	10.2
		9638	12.0		12.1 - 15.8	825	5.6
		10363	12.2		11.2 - 13.5	825	6.9
		10977	12.2		10.9 - 13.4	825	6.4
		11605	11.4		10.1 - 12.9	825	7.7
	O-41 Ef=8.0V	0	12.0	34	9.1 - 14.7	727	10.8
		1371	12.0		9.3 - 14.9	758	10.8
		9638	9.0		7.0 - 11.0	825	8.8
		10363	8.9		7.0 - 11.0	825	8.6
		10977	9.0		7.1 - 10.8	825	9.5
		11605	8.5		7.0 - 10.4	825	9.5
T2-825°C 0.3 A/cm^2	O-33 Ef=8.0V	0	24.0	45	19.0 - 30.4	787	21.0
		1371	20.9		16.2 - 25.4	825	20.8
		9638	15.0		12.3 - 18.0	825	16.2
		10363	12.0		10.0 - 13.8	825	19.5
		10977	13.9		11.5 - 16.1	825	16.6
		11605	13.5		11.2 - 15.8	825	16.8
	O-37 Ef=8.0V	0	24.0	56	19.1 - 30.7	735	22.6
		1371	21.0		17.0 - 24.7	825	18.0
		9638	20.2		16.8 - 23.5	825	20.8
		10363	19.4		16.2 - 23.4	825	21.6
		10977	19.5		16.2 - 23.3	825	18.0
		11605	21.0		17.2 - 28.3	781	21.3

TABLE 7

LIFE TEST RESULTS

OXIDE-COATED CATHODES

Test	Diode	Hours	Ip (ma)	Volts	Ip ± 20% V	Dip T°C	Ip @ 95%I
T3-825°C 0.225 A/cm^2	O-11 Ef=8.0V	0 3439 11958 12683 13297 13925	18.0 11.0 10.4 10.0 10.0 10.2	31	14.0 - 22.2 9.0 - 12.4 8.7 - 12.2 8.6 - 12.1 8.3 - 12.1 8.8 - 12.5	779 825 825 825 825 825	16.4 11.6 12.4 12.4 14.2 15.7
	O-15 Ef=8.0V	0 3439 11958 12683 13297 13925	18.0 14.2 12.5 12.0 12.0 12.2	28	13.9 - 23.5 11.3 - 18.0 10.0 - 14.7 10.0 - 14.4 10.0 - 13.9 10.0 - 14.2	769 825 825 825 825 825	16.6 13.5 11.3 11.2 12.4 15.7
T3-825°C 0.45 A/cm^2	O-7 Ef=8.0V	0 3439 11958 12683 13297 13925	36.0 20.0 17.3 17.0 17.0 37.2	34	28.0 - 45.5 17.0 - 22.4 14.5 - 20.4 14.2 - 20.2 14.2 - 20.2 28.2 - 48.5	783 825 825 825 825 797	33.5 32.8 23.0 21.5 25.1 31.5
	O-14 Ef=8.0V	0 3439 11958 12683 13297 13925	36.0 35.4 29.2 23.2 20.4 27.2	67	28.0 - 44.5 27.0 - 46.2 24.0 - 44.2 19.9 - 32.4 17.9 - 28.0 22.6 - 41.5	768 825 825 825 825 825	31.7 29.3 24.5 21.4 23.2 23.6

TABLE 8

LIFE TEST RESULTS

OXIDE-COATED CATHODES

Test	Diode	Hours	Ip (ma)	Volts	Ip ± 20% V	Dip T°C	Ip @ 95%I
T4-850°C 0.3 A/cm^2	O-22 Ef=8.0V	0 3439 11958 12683 13297	24.0 15.8 10.2 8.0 8.6	46	19.7 - 28.0 13.1 - 21.2 9.9 - 12.3 7.2 - 9.0 7.5 - 8.9	775 850 850 850 TUBE FAILURE	18.2 19.3 13.8 13.5
T4-850°C 0.6 A/cm^2	O-19 Ef=8.0V	0 3439 11958 12683 13297 13925	48.0 41.9 36.9 35.2 33.8 35.2	57.5	35.0 - 59.3 31.4 - 64.5 29.2 - 50.0 28.5 - 48.8 27.3 - 42.2 28.8 - 47.0	796 850 850 850 850 850	42.0 36.0 31.8 33.6 28.5 25.8
	O-20 Ef=8.0V	0 3439 11958 12683 13297 13925	48.0 41.4 28.7 13.9 23.4 25.9	70	36.8 - 60.0 32.0 - 55.3 23.9 - 31.9 11.8 - 15.2 20.8 - 26.5 22.2 - 29.0	769 850 850 850 850 850	42.6 37.5 30.0 24.0 29.7 22.5

4.0 LIFE BURNING AND TESTING OF OXIDE-COATED AND COATED-PARTICLE CATHODES WITH THREE DIFFERENT CATHODE ALLOYS

These diodes, which were constructed with three different cathode alloys according to the specifications described in Table 9, Life Test Procedures, Modification No. 1, were pretested and placed on life burning during June, 1969, of the eighth interim period of this study.

All the diodes showed the dip temperature to be the same as the operating temperature.

The test diodes were selected and placed on life burning with the highest possible cathode current that they would operate at in the space-charge region, in accordance with the specifications in Table No. 9.

The selected test conditions and life-burning characteristics are shown in Tables 10 (coated-particle cathodes) and 11 (oxide-coated cathodes).

The coated-particle cathodes with two cathode alloys show slumping above 0.3 A/cm^2 at 353 to 655 hours of life burning.

The oxide cathodes with three different cathode alloys show slumping in eight out of ten cases at all selected current densities.

TABLE 9

LIFE TEST PROCEDURES

MODIFICATION NO. 1

CATHODE	LIFE TEST TEMP.	REQ'D UNITS	CURRENT DENSITY ma/cm^2
Oxide Cathode	T_2	1	150
Using 220 Alloy	T_2	1	300
Nickel Base	T_3	1	225
(4 Units)	T_3	1	450
Oxide Cathode	T_2	1	150
Using Cathalloy	T_2	1	300
A-33 Nickel Base	T_3	1	225
(4 Units)	T_3	1	450
Oxide Cathode	T_2	1	150
Using 0.1% Zr in	T_2	1	300
Ni-pure Nickel Base	T_3	1	225
(4 Units)	T_3	1	450
Coated Particle	T_2	1	275
Cathode Using Cath-	T_2	1	550
alloy A-33 Nickel Base	T_3	1	415
(4 Units)	T_3	1	830
Coated Particle	T_2	1	275
Cathode Using 0.1%	T_2	1	550
Zr in Ni-pure Nickel Base	T_3	1	415
(4 Units)	T_3	1	830

TABLE 10

LIFE BURNING

COATED-POWDER CATHODES

Test	Diode	Hours	Ip (ma)	Volts	Ip ± 20% V	Dip T°C	Ip @ 95% I
T2-850°C CPC with 0.1% Zr in Ni-pure	N-16 0.15 A/cm^2	0	12.0	52	9.9 - 14.6		
		46	11.5		9.6 - 13.9		
		353	11.0		8.9 - 12.9		
	N-26 0.30 A/cm^2	0	24.0	25	19.0 - 28.0		
		46	18.2		15.3 - 20.8		
		353	15.2		13.2 - 16.9		
T3-850°C CPC with 0.1% Zr in Ni-pure	No. 13 0.225 A/cm^2	0	18.0	72	13.9 - 20.5		
		46	15.1		12.0 - 18.5		
		353	14.9		11.1 - 16.2		
	N-17 0.45 A/cm^2	0	36.0	57	26.6 - 43.0		
		46	25.2		25.2 - 36.4		
		353	23.0		23.0 - 31.3		
T2-825°C CPC with A33 Nickel	N-21 0.275 A/cm^2	0	19.0	38	17.0 - 21.8		
		23	14.2		12.4 - 16.3		
		655	36.4		30.0 - 43.2		
	N-31 0.55 A/cm^2	0	37.0	61	29.8 - 48.9		
		23	36.0		28.4 - 45.2		
		655	29.1		23.8 - 35.2		
T3-825°C CPC with A33 Nickel	N-4 0.415 A/cm^2	0	33.0	15	30.4 - 49.5		
		23	36.0		23.8 - 37.7		
		655	29.8		22.9 - 36.8		
	N-6 0.830 A/cm^2	0	66.0	49	54.2 - 86.0		
		23	63.2		49.8 - 81.0		
		655	31.9		27.8 - 36.9		

TABLE 11

LIFE BURNING

OXIDE-COATED CATHODES

Test	Diode	Hours	Ip (ma)	Volts	Ip ± 20% V	Dip T°C	Ip @ 95%I
T2-825°C Oxide with 0.1% Zr in Ni-pure	No.3 0.30 A/cm^2	0	24.0	39	19.0 - 29.9		
		24	17.0		14.3 - 25.4		
		307	13.4		10.8 - 16.0		
	No.1 0.15 A/cm^2	0	12.0	38	10.2 - 13.9		
		24	10.3		8.9 - 11.2		
		307	5.9		5.1 - 6.0		
T3-850°C Oxide with 0.1% Zr in Ni-pure	No.2 0.225 A/cm^2	0	18.0	38	15.4 - 26.2		
		23	16.4		13.0 - 19.8		
		330	6.2		5.8 - 6.7		
	No.4 0.45 A/cm^2	0	36.0	35	28.5 - 51.7		
		23	16.4		13.0 - 18.4		
		330	8.9		7.9 - 10.0		
T2-825°C Oxide with A33 Nickel	No.11 0.30 A/cm^2	0	24.0	58	18.0 - 30.6		
		47	22.8		17.6 - 28.3		
		353	20.4		15.9 - 24.8		
	No.22 0.15 A/cm^2	0	12.0	36	9.5 - 13.9		
		47	12.4		9.5 - 14.9		
		353	11.2		9.0 - 13.2		
T3-850°C Oxide with A33 Nickel	No.24 0.225 A/cm^2	0	18.0	36	14.0 - 22.4		
		47	16.9		13.1 - 20.4		
		353	9.2		7.9 - 10.0		
	No.12 0.45 A/cm^2	0	36.0	45	27.8 - 44.8		
		47	34.5		26.8 - 42.7		
		353	22.2		19.0 - 25.0		
T3-850°C Oxide with 220 Nickel	No.5 0.225 A/cm^2	0	18.0	34	14.2 - 23.8		
		77	12.0		10.4 - 13.4		
		268	4.9		4.2 - 4.9		
	No.1 0.45 A/cm^2	0	36.0	65	28.4 - 41.5		
		77	7.8		6.4 - 7.9		
		268	3.5		3.2 - 3.6		

5.0 PLANS FOR THE NINTH INTERIM PERIOD

During the next interim period of study from July 1 - September 30, 1969, the following programs will be followed:

a. Continue life testing of pore-dispenser cathodes now on life burning.

b. Continue life testing of oxide cathodes now on life burning.

c. Continue life testing of diodes constructed according to Modification No. 1 of the study.

6.0 CONCLUSIONS AND SUMMARY

The Raytheon Materials and Techniques Group, in conducting a study of the life capabilities of the pore-dispenser cathode and the oxide cathode, has drawn the following conclusions from 21 months of life burning under the conditions noted in Tables 1 through 11.

a. The pore-dispenser method is suitable for dc operation for at least 14,784 hours at current ranges of 0.2 A/cm^2 to 1.6 A/cm^2 and temperatures ranging from 950°C to 1100°C.

b. The standard barium/strontium-oxide cathodes are showing emission slump at current densities above 0.15 A/cm^2 from 11,605 to 13,925 hours. Though the emission level in these diodes is decaying, they should not be counted as failures at this point of life.

c. The diodes constructed with the cathode alloy modifications listed in Table 9 are showing slumping emission with oxide-coated cathodes. The coated-particle cathodes with A33 nickel alloy are showing some stability up to 0.45 A/cm^2 at 655 hours.

d. At this point, the only candidate for satisfying the objective of 1 A/cm^2 is the pore-dispenser cathode.